Part 27—Airworthiness Standards: Normal Category Rotorcraft

This change incorporates two amendments:

Amendment 27–31, Revision of Authority Citations, adopted December 20 and effective December 28, 1995; and

Amendment 27–32, Airworthiness Standards; Occupant Protection in Normal and Transport Category Rotorcraft, adopted March 8 and effective June 11, 1996. This amendment revises § 27.561.

Bold brackets enclose the most recently changed or added material.

Page Control Chart

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Suggest filing this transmittal at the beginning of the FAR. It will provide a method for determining that all changes have been received as listed in the current edition of AC 00–44, Status of Federal Aviation Regulations, and a check for determining if the FAR contains the proper pages.

The Regulatory Flexibility Act (RFA) of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis if a rule is expected to have a ''significant economic impact on a substantial number of small entities.'' FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The FAA does not expect the rule to have a significant economic impact on a substantial number of small manufacturers or operators.

Trade Impact Assessment

The rule will have no impact on trade for either U.S. firms doing business in foreign markets or foreign firms doing business in the United States. In the United States, foreign manufacturers must meet U.S. requirements, and thus will gain no competitive advantage. In foreign countries, U.S. manufacturers are not bound by parts 27 and 29 requirements and can choose whether or not to implement the provisions of this rule on the basis of competitive and other considerations. Also, the Joint Airworthiness Authority (JAA) and Transport Canada are both in the process of adopting this rule.

Federalism Implications

The regulations herein do not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this amendment does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed in the preamble and based on the findings in the Regulatory Flexibility Determination and the Trade Impact Assessment, the FAA has determined that these amendments are not major under Executive Order 12866. In addition, the FAA certifies that these amendments do not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. These amendments are considered nonsignificant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the amendments, including a Regulatory Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the Rules Docket (AGC–10), Docket No. 26392, 800 Independence Avenue, SW., Washington, DC 25890.

The Amendment

Accordingly, the Federal Aviation Administration amends 14 CFR parts 27 and 29 of the Federal Aviation Regulations as effective November 2, 1994.

The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, 1430; and 49 U.S.C. 106(g).

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authority upon the Federal Aviation Administration were recodified into positive law. This document updates the authority citations listed in the Code of Federal Regulations to reference the current law.

DATES: This final rule is effective December 28, 1995. Comments on this final rule must be received by March 1, 1996.

FOR FURTHER INFORMATION CONTACT: Karen Petronis, Office of the Chief Counsel, Regulations Division (AGC–210), Federal Aviation Administration, 800 Independence Ave., SW., Washington, DC 20591; telephone (202) 267–3073.

SUPPLEMENTARY INFORMATION: In July 1994, the Federal Aviation Act of 1958 and numerous other pieces of legislation affecting transportation in general were recodified. The statutory material became "positive law" and was recodified at 49 U.S.C. 1101 *et seq.*

The Federal Aviation Administration is amending the authority citations for its regulations in Chapter I of 14 CFR to reflect the recodification of its statutory authority. No substantive change was intended to any statutory authority by the recodification, and no substantive change is introduced to any regulation by this change.

Although this action is in the form of a final rule and was not preceded by notice and an opportunity for public comment, comments are invited on this action. Interested persons are invited to comment by submitting such written data, views, or arguments as they may desire by March 1, 1996. Comments should identify the rules docket number (Docket No. 28417) and be submitted to the address specified under the caption "FOR FURTHER INFORMATION CONTACT."

Because of the editorial nature of this change, it has been determined that prior notice is unnecessary under the Administrative Procedure Act. It has also been determined that this final rule is not a "significant regulatory action" under Executive Order 12866, nor is it a significant action under DOT regulatory policies and procedures (44 FR 11034, February 26, 1979). Further, the editorial nature of this change has no known or anticipated economic impact; accordingly, no regulatory analysis has been prepared.

Adoption of the Amendment

In consideration of the forgoing, the Federal Aviation Administration amends 14 CFR Chapter I effective December 28, 1995.

The authority citation for part 27 is revised to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44704.

Amendment 27–32

Airworthiness Standards; Occupant Protection in Normal and Transport Category Rotorcraft

Adopted: March 8, 1996 **Effective: June 11, 1996**

(Published in 61 FR 10436, March 13, 1996)

SUMMARY: The Federal Aviation Administration (FAA) is amending the airworthiness standards to improve occupant protection in normal and transport category rotorcraft. These amended standards significantly increase the static design ultimate inertial load factors for restraining heavy items located above or behind the occupied areas during emergency landings. These increased load factors also apply to certain cargo and baggage compartments. These amendments further complement and enhance the standards previously

These amendments are based on Notice of Proposed Rulemaking (NPRM) No. 94–8, which was published in the *Federal Register* on April 11, 1994 (59 FR 17156). That notice proposed to amend the occupant protection airworthiness standards of 14 CFR parts 27 and 29 (parts 27 and 29) to increase the ultimate inertial load factors in §§ 27.561(c) and 29.561(c) and to add a new 1.5g rearward design load factor to §§ 27.561(b) and 29.561(b). The amended standards of §§ 27.561(c) and 29.561(c) would apply to restraining heavy items located above and behind the cabin and other occupied areas against the loads created during emergency landings; and the amended standards of §§ 27.561(b) and 29.561(b) would apply to restraining and protecting occupants and restraining heavy items in the cabin and other occupied areas against the loads created during emergency landings. In addition, the amended standards of §§ 27.561(b) and (c) and 29.561(b) and (c) would apply to current cargo and baggage compartment standards by their reference within the text of §§ 27.787 and 29.787.

The Crash Resistant Fuel Systems (CRFS) in Normal and Transport Category Rotorcraft Final Rule, Amendments 27–30 and 29–35 (59 FR 50380, October 3, 1994), amended the fuel tank and compartment standards of §§ 27.963 and 29.963 (which utilized the inertial factors contained in §§ 27.561 and 29.561, respectively) to specifically state the CRFS inertial factor standards in §§ 27.952(b)(2) and 29.952(b)(2). However, the specific inertial factors adopted in §§ 27.952(b)(2) and 29.952(b)(2) for fuel tanks located above or behind the occupied areas are lower than those factors adopted in these amendments. The FAA will consider whether further rulemaking is necessary to increase the inertial load factors for CRFS design in §§ 27.952(b)(2) and 29.952(b)(2) to the levels of those adopted in §§ 27.561(c) and 29.561(c) of these amendments.

In summary, occupant protection will be enhanced through the increased strength requirements for retention of items of mass, such as engines, transmissions, and baggage and cargo compartment contents located above or behind occupied areas. These amended standards stem from recommendations from the Aviation Rulemaking Advisory Committee (ARAC) to increase certain design inertial load factors. These amended standards will complement and enhance the occupant protection standards adopted by Amendments 27–25 and 29–29 (54 FR 47310, November 13, 1989) for survivable emergency landings.

Discussion of Comments

Interested persons have been afforded an opportunity to participate in the making of these amendments. Due consideration has been given to the comments received from the four commenters. The commenters are the Civil Aviation Authority (CAA) Australia, the Airline Pilots Association (ALPA), the Association Europeene des Constructeurs de Material Aerospatial (AECMA), and the National Transportation Safety Board (NTSB).

The CAA agrees that increased design inertial load factors are appropriate but questions the logic in the difference between design factors for occupant restraint and protection previously adopted for interior items and the proposed factors for restraint of external items. This commenter recommends adoption of the larger design inertial factors found in §§ 27.561(b) and 29.561(b) applicable to restraint of occupants and cabin items rather than the factors proposed. The commenter highlights the differences between the two sets of design inertial factors.

ALPA supports the proposal but requests that the FAA determine if the proposed 1.5g rearward inertial factor for seats is sufficient in light of a possible emergency landing scenario in which the rotorcraft would itself rotate 180 degrees and cause the seats and occupants to exceed the 1.5g design inertial load factor.

AECMA notes that publication and prompt adoption of the final rule as proposed are essential to harmonize these sections of the Federal Aviation Regulations with the comparable European Joint Aviation Regulations (JAR) 27 and 29 Rotorcraft Standards.

The NTSB comments that the proposed standards represent a significant advancement in occupant protection and in crashworthiness of normal and transport category rotorcraft and supports the proposal.

The FAA understands ALPA's concern about the adequacy of the 1.5g rearward load factor in the event of an emergency landing impact in which the rotorcraft fuselage is either fully or partially reversed for some time interval during the overall impact sequence. Some cases of reverse impact could exceed the proposed rearward load factor. However, FAA research has considered the overall spectrum of reverse impacts and that research shows that occurrences of severe, sustained reverse impacts are remote. This research also shows that reverse impacts constitute an extremely small portion of all rotorcraft impacts. In addition, the research shows that the gravity forces felt by occupants are significantly less in most reverse impacts because of the larger crushing distances inherent in most rotorcraft aft fuselage structures and because the reverse direction of the impact is typically not sustained. Additional fuselage motion such as tumbling and further rotation usually occur, thus the full impact is not in a reverse direction. Therefore, the total impact energy dissipated in a reverse impact is considered minimal. In addition, the complementary inertial design factors in §§ 27.561(b) and 29.561(b), as well as the companion dynamic test standards in §§ 27.562 and 29.562, inherently provide strength for occupant protection in the event of a reverse impact. Therefore, the FAA has determined that the 1.5g rearward inertial factor is an adequate, practical safety standard.

In response to AECMA's concern that the publication date of this final rule correspond to the publication date of the JAR amendment, the FAA is committed to processing this final harmonized rule so that it can be published as near as possible to the publication date of the JAR.

The CAA also recommends application of a 1.33 inertial attachment factor for litter and berth installations as a logical application of the seat design standard found in §§ 27.785(f)(2) and 29.785(f)(2) but recognizes that this request exceeds the scope of the proposal. The CAA further recommends a research program to address litter installations and litter occupant protection. To improve protection of litter occupants, the FAA anticipates conducting an internal FAA research program to address litter installations for airplanes and rotorcraft.

After considering all of the comments, the FAA has determined that air safety and the public interest require adoption of the amendments as proposed.

Regulatory Evaluation Summary

Proposed changes to federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effect of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) Will generate benefits exceeding its costs and is not significant as defined in Executive Order 12866; (2) is not significant as defined in DOT's Policies and Procedures; (3) will not have a significant impact on a substantial number of small entities; and (4) will not affect international trade. These analyses, available in the docket, are summarized below.

Cost-Benefit Analysis

The increased forward, sideward, and downward load factors can be accommodated without changing current design practices. In many cases, sizable increases in load factors have been achieved by the use of larger bolts and/or fasteners and minor reinforcements to attach items of mass to the rotorcraft structure. The addition of 1.5g rearward load factors will require no design or production modifications because the 12g and 16g forward load factors of the new and current standards will inherently result in sufficient structural strength to meet this rearward requirement.

Consequently, the amendments that add and revise requirements will impose little or no incremental costs on rotorcraft manufacturers. Additionally, they will impose no or minimal weight penalties and operating costs on rotorcraft operators.

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by Federal regulations. The RFA requires a Regulatory Flexibility Analysis if a rule has significant economic impact on a substantial number of small entities. FAA Order 2100.14A outlines FAA's procedures and criteria for implementing the RFA. The FAA has determined that this rule will not have a significant economic impact on a substantial number of small manufacturers or operators of rotorcraft because there are no small rotorcraft manufacturers, as that term is defined in the Order.

International Trade Impact Assessment

This rule will not constitute a barrier to international trade, including the export of American goods and services to foreign countries and the import of foreign goods and services into the United States. Each applicant for a new type certificate for a transport or normal category rotorcraft, whether the applicant be U.S. or foreign, will be required to show compliance with this rule. This rule will have no effect on the sale of U.S. rotorcraft in foreign markets and the sale of foreign rotorcraft in the United States.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the states, on the relationships between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this regulation will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons stated above, including the findings of the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that this regulation will not have a significant economic impact on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. This rule is not considered significant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of this regulation, including a Regulatory Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under the section entitled ''FOR FURTHER INFORMATION CONTACT.''

The Amendments

Accordingly, the Federal Aviation Administration amends 14 CFR parts 27 and 29 of the Federal Aviation Regulations effective June 11, 1996.

The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44704.

General

§ 27.301 Loads.

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the rotorcraft. These loads must be distributed to closely approximate or conservatively represent actual conditions.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

§ 27.303 Factor of safety.

Unless otherwise provided, a factor of safety of 1.5 must be used. This factor applies to external and inertia loads unless its application to the resulting internal stresses is more conservative.

§ 27.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental or permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure. This must be shown by—

(1) Applying ultimate loads to the structure in a static test for at least three seconds; or

(2) Dynamic tests simulating actual load application.

§ 27.307 Proof of structure.

(a) [Compliance with the strength and deformation requirements of this subpart must be shown for each critical loading condition accounting for the environment to which the structure will be exposed in operation. Structural analysis (static or fatigue) may be used only if the structure conforms to those structures for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made.]

(b) Proof of compliance with the strength requirements of this subpart must include—

(1) Dynamic and endurance tests of rotors, rotor drives, and rotor controls;

(2) Limit load tests of the control system, including control surfaces;

(3) Operation tests of the control system;

(4) Flight stress measurement tests;

(5) Landing gear drop tests; and

(6) Any additional tests required for new or unusual design features.

(Amdt. 27–3, Eff. 10/17/68); [(Amdt. 27–26, Eff. 4/5/90)]

§ 27.309 Design limitations.

The following values and limitations must be established to show compliance with the structural requirements of this subpart:

(a) The design maximum weight.

(b) The main rotor r.p.m. ranges, power on and power off.

(c) The maximum forward speeds for each main rotor r.p.m. within the ranges determined under paragraph (b) of this section.

(d) The maximum rearward and sideward flight speeds.

(e) The center of gravity limits corresponding to the limitations determined under paragraphs (b), (c), and (d) of this section.

(f) The rotational speed ratios between each powerplant and each connected rotating component.

(g) The positive and negative limit maneuvering load factors.

FLIGHT LOADS

§ 27.321 General.

(a) The flight load factor must be assumed to act normal to the longitudinal axis of the rotorcraft, and to be equal in magnitude and opposite in direction to the rotorcraft inertia load factor at the center of gravity.

§ 27.337 Limit maneuvering load factor.

[The rotorcraft must be designed for—

[(a) A limit maneuvering load factor ranging from a positive limit of 3.5 to a negative limit of -1.0; or

[(b) Any positive limit maneuvering load factor not less than 2.0 and any negative limit maneuvering load factor of not less than -0.5 for which—

[(1) The probability of being exceeded is shown by analysis and flight tests to be extremely remote; and

[(2) The selected values are appropriate to each weight condition between the design maximum and design minimum weights.]

[(Amdt. 27–26, Eff. 4/5/90)]

§ 27.339 Resultant limit maneuvering loads.

The loads resulting from the application of limit maneuvering load factors are assumed to act at the center of each rotor hub and at each auxiliary lifting surface, and to act in directions, and with distributions of load among the rotors and auxiliary lifting surfaces, so as to represent each critical maneuvering condition, including power-on and power-off flight with the maximum design rotor tip speed ratio. The rotor tip speed ratio is the ratio of the rotorcraft flight velocity component in the plane of the rotor disc to the rotational tip speed of the rotor blades, and is expressed as follows:

$$\mu = \frac{V \cos a}{\Omega R}$$

Where—

V = The airspeed along flight path (f.p.s.);

a = The angle between the projection, in the plane of symmetry, of the axis of no feathering and a line perpendicular to the flight path (radians, positive when the axis is pointing aft);

omega = The angular velocity of rotor (radians per second); and

R = The rotor radius (ft).

(Amdt. 27–11, Eff. 2/1/77)

[(a) Each rotorcraft must be designed for the loads resulting from the maneuvers specified in paragraphs (b) and (c) of this section with—

[(1) Unbalanced aerodynamic moments about the center of gravity which the aircraft reacts to in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces; and

[(2) Maximum main rotor speed.

[(b) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from zero up to 0.6 V_{NE}—

[(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stops or by the pilot force specified in § 27.395(a);

[(2) Attain a resulting sideslip angle or 90°, whichever is less; and

[(3) Return the directional control suddenly to neutral.

[(c) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from 0.6 V_{NE} up to V_{NE} or V_H, whichever is less—

[(1) Displace the cockpit directional control suddenly to the maximum deflection limited by, the control stops or by the pilot force specified in § 27.395(a);

[(2) Attain a resulting sideslip angle or 15°, whichever is less, at the lesser speed of V_{NE} or V_H;

[(3) Vary the sideslip angles of paragraphs (b)(2) and (c)(2) of this section directly with speed; and

[(4) Return the directional control suddenly to neutral.]

[(Amdt. 27–26, Eff. 4/5/90)]

§ 27.361 Engine torque.

(a) For turbine engines, the limit torque may not be less than the highest of—

(1) The mean torque for maximum continuous power multiplied by 1.25;

(2) The torque required by § 27.923;

(3) The torque required by § 27.927; or

(2) Two, three, and four, for engines with four, three, and two cylinders, respectively.

(Amdt. 27–23, Eff. 10/3/88)

CONTROL SURFACE AND SYSTEM LOADS

§ 27.391 General.

Each auxiliary rotor, each fixed or movable stabilizing or control surface, and each system operating any flight control must meet the requirements of §§ 27.395, 27.397, 27.399, 27.401, 27.403, 27.411, 27.413, and 27.427.

(Amdt. 27–26, Eff. 4/5/90)

§ 27.395 Control system.

(a) The part of each control system from the pilot's controls to the control stops must be designed to withstand pilot forces of not less than—

(1) The forces specified in § 27.397; or

(2) If the system prevents the pilot from applying the limit pilot forces to the system, the maximum forces that the system allows the pilot to apply, but not less than 0.60 times the forces specified in § 27.397.

(b) Each primary control system, including its supporting structure, must be designed as follows:

(1) The system must withstand loads resulting from the limit pilot forces prescribed in § 27.397.

(2) Notwithstanding paragraph (b)(3) of this section, when power-operated actuator controls or power boost controls are used, the system must also withstand the loads resulting from the force output of each normally energized power device, including any single power boost or actuator system failure.

(3) If the system design or the normal operating loads are such that a part of the system cannot react to the limit pilot forces prescribed in § 27.397, that part of the system must be designed to withstand the maximum loads that can be obtained in normal operation. The minimum design loads must, in any case, provide a rugged system for service use, including pilot forces specified in § 27.397, without yielding.

(Amdt. 27–26, Eff. 4/5/90)

§ 27.397 Limit pilot forces and torques.

(a) Except as provided in paragraph (b) of this section, the limit pilot forces are as follows:

(1) For foot controls, 130 pounds.

(2) For stick controls, 100 pounds fore and aft, and 67 pounds laterally.

(b) For flap, tab, stabilizer, rotor brake, and landing gear operating controls, the following apply (R=radius in inches):

(1) Crank, wheel, and level controls, [1+R] 3/×50 pounds, but not less than 50 pounds nor more than 100 pounds for hand operated controls or 130 pounds for foot operated controls, applied at any angle within 20 degrees of the plane of motion of the control.

(2) Twist controls, 80R pounds.

(Amdt. 27–11, Eff. 2/1/77)

§ 27.399 Dual control system.

Each dual primary flight control system must be designed to withstand the loads that result when pilot forces of 0.75 times those obtained under § 27.395 are applied—

(a) In opposition; and

(b) In the same direction.

§ 27.401 [Removed]

§ 27.403 [Removed]

§ 27.411 Ground clearance: Tail rotor guard.

(a) It must be impossible for the tail rotor to contact the landing surface during a normal landing.

(b) If a tail rotor guard is required to show compliance with paragraph (a) of this section—

(1) Suitable design loads must be established for the guard; and

(2) The guard and its supporting structure must be designed to withstand those loads.

(b) To meet the design criteria of paragraph (a) of this section, in the absence of more rational data, both of the following must be met:

(1) One hundred percent of the maximum loading from the symmetrical flight conditions acts on the surface on one side of the plane of symmetry, and no loading acts on the other side.

(2) Fifty percent of the maximum loading from the symmetrical flight conditions acts on the surface on each side of the plane of symmetry but in opposite directions.

(c) For empennage arrangements where the horizontal tail surfaces are supported by the vertical tail surfaces, the vertical tail surfaces and supporting structure must be designed for the combined vertical horizontal surface loads resulting from each prescribed flight condition, considered separately. The flight conditions must be selected so the maximum design loads are obtained on each surface. In the absence of more rational data, the unsymmetrical horizontal tail surface loading distributions described in this section must be assumed.

(Amdt. 27–26, Eff. 4/5/90); (Amdt. 27–27, Eff. 10/22/90)

GROUND LOADS

§ 27.471 General.

(a) *Loads and equilibrium.* For limit ground loads—

(1) The limit ground loads obtained in the landing conditions in this part must be considered to be external loads that would occur in the rotorcraft structure if it were acting as a rigid body; and

(2) In each specified landing condition, the external loads must be placed in equilibrium with linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centers of gravity.* The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element.

(b) Unless otherwise prescribed, for each specified landing condition, the rotorcraft must be designed for a limit load factor of not less than the limit inertia load factor substantiated under § 27.725.

(Amdt. 27–2, Eff. 2/25/68)

§ 27.475 Tires and shock absorbers.

Unless otherwise prescribed, for each specified landing condition, the tires must be assumed to be in their static position and the shock absorbers to be in their most critical position.

§ 27.477 Landing gear arrangement.

Sections 27.235, 27.479 through 27.485, and 27.493 apply to landing gear with two wheels aft, and one or more wheels forward, of the center of gravity.

§ 27.479 Level landing conditions.

(a) *Attitudes.* Under each of the loading conditions prescribed in paragraph (b) of this section, the rotorcraft is assumed to be in each of the following level landing attitudes:

(1) An attitude in which all wheels contact the ground simultaneously.

(2) An attitude in which the aft wheels contact the ground with the forward wheels just clear of the ground.

(b) *Loading conditions.* The rotorcraft must be designed for the following landing loading conditions:

(1) Vertical loads applied under § 27.471.

(2) The loads resulting from a combination of the loads applied under paragraph (b)(1) of this section with drag loads at each wheel of not less than 25 percent of the vertical load at that wheel.

(3) If there are two wheels forward, a distribution of the loads applied to those wheels under paragraphs (b)(1) and (2) of this section in a ratio of 40:60.

(c) *Pitching moments.* Pitching moments are assumed to be resisted by—

(a) The rotorcraft is assumed to be in the maximum nose-up attitude allowing ground clearance by each part of the rotorcraft.

(b) in this attitude, ground loads are assumed to act perpendicular to the ground.

§ 27.483 One-wheel landing conditions.

For the one-wheel landing condition, the rotorcraft is assumed to be in the level attitude and to contact the ground on one aft wheel. In this attitude—

(a) The vertical load must be the same as that obtained on that side under § 27.479(b)(1); and

(b) The unbalanced external loads must be reacted by rotorcraft inertia.

§ 27.485 Lateral drift landing conditions.

(a) The rotorcraft is assumed to be in the level landing attitude, with—

(1) Side loads combined with one-half of the maximum ground reactions obtained in the level landing conditions of § 27.479(b)(1); and

(2) The loads obtained under paragraph (a)(1) of this section applied—

(i) At the ground contact point; or

(ii) For full-swiveling gear, at the center of the axle.

(b) The rotorcraft must be designed to withstand, at ground contact—

(1) When only the aft wheels contact the ground, side loads of 0.8 times the vertical reaction acting inward on one side, and 0.6 times the vertical reaction acting outward on the other side, all combined with the vertical loads specified in paragraph (a) of this section; and

(2) When all wheels contact the ground simultaneously—

(i) For the aft wheels, the side loads specified in paragraph (b)(1) of this section; and

(ii) For the forward wheels, a side load of 0.8 times the vertical reaction combined with the vertical load specified in paragraph (a) of this section.

§ 27.479(a)(2); and

(b) The structure must be designed to withstand, at the ground contact point of each wheel with brakes, a drag load at least the lesser of—

(1) The vertical load multiplied by a coefficient of friction of 0.8; and

(2) The maximum value based on limiting brake torque.

§ 27.497 Ground loading conditions: Landing gear with tail wheels.

(a) *General.* Rotorcraft with landing gear with two wheels forward, and one wheel aft, of the center of gravity must be designed for loading conditions as prescribed in this section.

(b) *Level landing attitude with only the forward wheels contacting the ground.* In this attitude—

(1) The vertical loads must be applied under §§ 27.471 through 27.475;

(2) The vertical load at each axle must be combined with a drag load at that axle of not less than 25 percent of that vertical load; and

(3) Unbalanced pitching moments are assumed to be resisted by angular inertia forces.

(c) *Level landing attitude with all wheels contacting the ground simultaneously.* In this attitude, the rotorcraft must be designed for landing loading conditions as prescribed in paragraph (b) of this section.

(d) *Maximum nose-up attitude with only the rear wheel contacting the ground.* The attitude for this condition must be the maximum nose-up attitude expected in normal operation, including autorotative landings. In this attitude—

(1) The appropriate ground loads specified in paragraphs (b)(1) and (2) of this section must be determined and applied, using a rational method to account for the moment arm between the rear wheel-ground reaction and the rotorcraft center of gravity; or

(2) The probability of landing with initial contact on the rear wheel must be shown to be extremely remote.

(e) *Level landing attitude with only one forward wheel contacting the ground.* In this attitude, the ground reactions obtained for that wheel under paragraphs (b) and (c) of this section. In this condition, the side loads must be—

(i) For the forward wheels, 0.8 times the vertical reaction (on one side) acting inward, and 0.6 times the vertical reaction (on the other side) acting outward; and

(ii) For the rear wheel, 0.8 times the vertical reaction.

(2) The loads specified in paragraph (f)(1) of this section must be applied—

(i) At the ground contact point with the wheel in the trailing position (for non-full swiveling landing gear with a lock, steering device, or shimmy damper to keep the wheel in the trailing position); or

(ii) At the center of the axle (for full swiveling landing gear without a lock, steering device, or shimmy damper).

(g) *Braked roll conditions in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, and with the shock absorbers in their static positions, the rotorcraft must be designed for braked roll loads as follows:

(1) The limit vertical load must be based on a limit vertical load factor of not less than—

(i) 1.0, for the attitude specified in paragraph (b) of this section; and

(ii) 1.33, for the attitude specified in paragraph (c) of this section.

(2) For each wheel with brakes, a drag load must be applied, at the ground contact point, of not less than the lesser of—

(i) 0.8 times the vertical load; and

(ii) The maximum based on limiting brake torque.

(h) *Rear wheel turning loads in the static ground attitude.* In the static ground attitude, and with the shock absorbers and tires in their static positions, the rotorcraft must be designed for rear wheel turning loads as follows:

(1) A vertical ground reaction equal to the static load on the rear wheel must be combined with an equal sideload.

is a lock, steering device or shimmy damper (the rear wheel being assumed to be in the trailing position).

(i) *Taxiing condition.* The rotorcraft and its landing gear must be designed for loads that would occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation.

§ 27.501 Ground loading conditions: Landing gear with skids.

(a) *General.* Rotorcraft with landing gear with skids must be designed for the loading conditions specified in this section. In showing compliance with this section, the following apply:

(1) The design maximum weight, center of gravity, and load factor must be determined under §§ 27.471 through 27.475.

(2) Structural yielding of elastic spring members under limit loads is acceptable.

(3) Design ultimate loads for elastic spring members need not exceed those obtained in a drop test of the gear with—

(i) A drop height of 1.5 times that specified in § 27.725; and

(ii) An assumed rotor lift of not more than 1.5 times that used in the limit drop tests prescribed in § 27.725.

(4) Compliance with paragraphs (b) through (e) of this section must be shown with—

(i) The gear in its most critically deflected position for the landing condition being considered; and

(ii) The ground reactions rationally distributed along the bottom of the skid tube.

(b) *Vertical reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the vertical reactions must be applied as prescribed in paragraph (a) of this section.

(c) *Drag reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

the ground along the bottom of both skids, the following apply:

(1) The vertical ground reaction must be—

(i) Equal to the vertical loads obtained in the condition specified in paragraph (b) of this section; and

(ii) Divided equally among the skids.

(2) The vertical ground reactions must be combined with a horizontal sideload of 25 percent of their value.

(3) [The total sideload must be applied equally between the skids and along the length of the skids.]

(4) The unbalanced moments are assumed to be resisted by angular inertia.

(5) The skid gear must be investigated for—

(i) Inward acting sideloads; and

(ii) Outward acting sideloads.

(e) *One-skid landing loads in the level attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of one skid only, the following apply:

(1) The vertical load on the ground contact side must be the same as that obtained on that side in the condition specified in paragraph (b) of this section.

(2) The unbalanced moments are assumed to be resisted by angular inertia.

(f) *Special conditions.* In addition to the conditions specified in paragraphs (b) and (c) of this section, the rotorcraft must be designed for the following ground reactions:

(1) A ground reaction load acting up and aft at an angle of 45° to the longitudinal axis of the rotorcraft. This load must be—

(i) Equal to 1.33 times the maximum weight;

(ii) Distributed symmetrically among the skids;

(iii) Concentrated at the forward end of the straight part of the skid tube; and

(iv) Applied only to the forward end of the skid tube and its attachment to the rotorcraft.

(2) With the rotorcraft in the level landing attitude, a vertical ground reaction load equal to

(Amdt. 27–2, Eff. 2/25/68); [(Amdt. 27–26, Eff. 4/5/90)]

§ 27.505 Ski landing conditions.

If certification for ski operation is requested, the rotorcraft, with skis, must be designed to withstand the following loading conditions (where *P* is the maximum static weight on each ski with the rotorcraft at design maximum weight, and *n* is the limit load factor determined under § 27.473(b).

(a) Up-load conditions in which—

(1) A vertical load of *Pn* and a horizontal load of *Pn*/4 are simultaneously applied at the pedestal bearings; and

(2) A vertical load of 1.33 *P* is applied at the pedestal bearings.

(b) A side-load condition in which a side load of 0.35 *Pn* is applied at the pedestal bearings in a horizontal plane perpendicular to the centerline of the rotorcraft.

(c) A torque-load condition in which a torque load of 1.33 *P* (in foot pounds) is applied to the ski about the vertical axis through the centerline of the pedestal bearings.

WATER LOADS

§ 27.521 Float landing conditions.

If certification for float operation is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under § 27.473(b) or assumed to be equal to that determined for wheel landing gear):

(a) Up-load conditions in which—

(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the center of gravity; and

(2) The vertical load prescribed in paragraph (a)(1) of this section is applied simultaneously with an aft component of 0.25 times the vertical component.

(b) A side-load condition in which—

MAIN COMPONENT REQUIREMENTS

§ 27.547 Main rotor structure.

(a) Each main rotor assembly (including rotor hubs and blades) must be designed as prescribed in this section.

(b) [Reserved]

(c) The main rotor structure must be designed to withstand the following loads prescribed in §§ 27.337 through 27.341:

(1) Critical flight loads.

(2) Limit loads occurring under normal conditions of autorotation. For this condition, the rotor r.p.m. must be selected to include the effects of altitude.

(d) The main rotor structure must be designed to withstand loads simulating—

(1) For the rotor blades, hubs, and flapping hinges, the impact force of each blade against its stop during ground operation; and

(2) Any other critical condition expected in normal operation.

(e) The main rotor structure must be designed to withstand the limit torque at any rotational speed, including zero. In addition:

(1) The limit torque need not be greater than the torque defined by a torque limiting device (where provided), and may not be less than the greater of—

(i) The maximum torque likely to be transmitted to the rotor structure in either direction; and

(ii) The limit engine torque specified in § 27.361.

(2) The limit torque must be distributed to the rotor blades in a rational manner.

(Amdt. 27–3, Eff. 10/17/68)

§ 27.549 Fuselage, landing gear, and rotor pylon structures.

(a) Each fuselage, landing gear, and rotor pylon structure must be designed as prescribed in this section. Resultant rotor forces may be represented

27.497, 27.501, 27.505, and 27.521; and

(3) The loads prescribed in § 27.547(d)(2) and (e).

(c) Auxiliary rotor thrust, and the balancing air and inertia loads occurring under accelerated flight conditions, must be considered.

(d) Each engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.

(Amdt. 27–3, Eff. 10/17/68)

EMERGENCY LANDING CONDITIONS

§ 27.561 General.

(a)The rotorcraft, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this section to protect the occupants under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when—

(1) Proper use is made of seats, belts, and other safety design provisions;

(2) The wheels are retracted (where applicable); and

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g, after the intended displacement of the seat device.

[(v) Rearward—1.5g]

(c) The supporting structure must be designed to restrain, under any ultimate inertial load up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmissions, and engines. The items of below the passenger floor level must be designed to resist the following ultimate inertial factors and loads and to protect the fuel tanks from rupture when those loads are applied to that area:

(i) Upward—1.5g.

(ii) Forward—4.0g.

(iii) Sideward—2.0g.

(iv) Downward—4.0g.

(Amdt. 27–3, Eff. 10/17/68); (Amdt. 27–25, Eff. 12/13/89); (Amdt. 27–30, Eff. 11/2/94); [(Amdt. 27–32, Eff. 6/11/96)]

[27.562 Emergency landing dynamic conditions.]

[(a) The rotorcraft, although it may be damaged in an emergency crash landing, must be designed to reasonably protect each occupant when—

[(1) The occupant properly uses the seats, safety belts, and shoulder harnesses provided in the design; and

[(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

[(b) Each seat type design or other seating device approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat in accordance with the following criteria. The tests must be conducted with an occupant, simulated by a 170-pound anthropomorphic test dummy (ATD), as defined by 49 CFR 572, subpart B, or its equivalent, sitting in the normal upright position.

[(1) A change in downward velocity of not less than 30 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is canted upward 60° with respect to the impact velocity vector, and the rotorcraft's lateral axis is perpendicular to a vertical plane containing the impact velocity vector and the rotorcraft's longitudinal axis. Peak floor deceleration must occur in not more than 0.031 seconds after impact and must reach a minimum of 30g's.

impact velocity vector, and the rotorcraft's vertical axis is perpendicular to a horizontal plane containing the impact velocity vector. Peak floor deceleration must occur in not more than 0.071 seconds after impact and must reach a minimum of 18.4g's.

[(3) When floor rails or floor or sidewall attachment devices are used to attach the seating devices to the airframe structure for the conditions of this section, the rails or devices must be misaligned with respect to each other by at least 10° vertically (i.e., pitch out of parallel, and by at least a 10° lateral roll, with the directions optional, to account for possible floor warp.

[(c) Compliance with the following must be shown:

[(1) The seating device system must remain intact although it may experience separation intended as part of its design.

[(2) The attachment between the seating device and the airframe structure must remain intact, although the structure may have exceeded its limit load.

[(3) The ATD's shoulder harness strap or straps must remain on or in the immediate vicinity of the ATD's shoulder during the impact.

[(4) The safety belt must remain on the ATD's pelvis during the impact.

[(5) The ATD's head either does not contact any portion, of the crew or passenger compartment, or if contact is made, the head impact does not exceed a head injury criteria (HIC) of 1,000 as determined by this equation.

$$HIC = (t_2 - t_1)\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}$$

Where: a(t) is the resultant acceleration at the center of gravity of the head form expressed as a multiple of g (the acceleration of gravity) and $t_2 - t_1$ is the time duration, in seconds, of major head impact, not to exceed 0.05 seconds.

[(6) Loads in individual upper torso harness straps must not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the

[(Amdt. 27–25, Eff. 12/13/89)]

§ 27.563 Structural ditching provisions.

[If certification with ditching provisions is requested, structural strength for ditching must meet the requirements of this section and § 27.801(e).

[(a) *Forward speed landing conditions.* The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 30 knots in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical descent velocity may not be less than 5 feet per second relative to the mean water surface. Rotor lift may be used to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown.

[(b) *Auxiliary or emergency float conditions.*

[(1) *Floats fixed or deployed before initial water contact.* In addition to the landing loads in paragraph (a) of this section, each auxiliary or emergency float, of its support and attaching structure in the airframe or fuselage, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float buoyancy load must be applied. The highest likely buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under § 27.801(d). Maximum roll and pitch angles determined from compliance with § 27.801(d) may be used, if significant, to determine the extent of immersion of each float. If the floats are deployed in flight, appropriate air loads derived from the flight limitations with the floats deployed shall be used in substantiation of the using a relative limit speed of 20 knots between the rotorcraft and the water. The vertical load may not be less than the highest likely buoyancy load determined under paragraph (b)(1) of this section.]

(Amdt. 27–11, Eff. 2/1/77); [(Amdt. 27–26, Eff. 4/5/90)]

FATIGUE EVALUATION

§ 27.571 Fatigue evaluation of flight structure.

(a) [*General.* Each portion of the flight structure (the flight structure includes rotors, rotor drive systems between the engines and the rotor hubs, controls, fuselage, landing gear, and their related primary attachments), the failure of which could be catastrophic, must be identified and must be evaluated under paragraph (b), (c), (d) or (e) of this section. The following apply to each fatigue evaluation:]

(1) The procedure for the evaluation must be approved.

(2) The locations of probable failure must be determined.

(3) Inflight measurement must be included in determining the following:

(i) Loads or stresses in all critical conditions throughout the range of limitations in § 27.309, except that maneuvering load factors need not exceed the maximum values expected in operation.

(ii) The effect of altitude upon these loads or stresses.

(4) [The loading spectra must be as severe as those expected in operation including, but not limited to, external cargo operations, if applicable, and ground-air-ground cycles. The loading spectra must be based on loads or stresses determined under paragraph (a)(3) of this section.]

(b) *Fatigue tolerance evaluation.* It must be shown that the fatigue tolerance of the structure ensures that the probability of catastrophic fatigue failure is extremely remote without establishing

(1) It must be shown that all partial failures will become readily detectable under inspection procedures furnished under section A27.4 of appendix A.

(2) The interval between the time when any partial failure becomes readily detectable under paragraph (d)(1) of this section, and the time when any such failure is expected to reduce the remaining strength of the structure to limit or maximum attainable loads (whichever is less), must be determined.

(e) *Combination of replacement time and failsafe evaluations.* A component may be evaluated under a combination of paragraphs (c) and (d) of this section. For such component it must be shown that the probability of catastrophic failure is extremely remote with an approved combination of replacement time, inspection intervals, and related procedures furnished under section A27.4 of appendix A.

(Amdt. 27–3, Eff. 10/17/68); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–18, Eff. 10/14/80); [(Amdt. 27–26, Eff. 4/5/90)]